Late Pleistocene Dinoflagellate Cysts from Bulahdelah, northern New South Wales

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A Late Pleistocene dinoflagellate microflora has been recovered from the water bore WRC 39275 near Bulahdelah, N.S.W. Species present include *Protoperidinium* (*Protoperidinium* sect. *Quinquecuspis*) *leonis* (Pavillard), *Tuberculodinium vancampoae* (Rossignol), *Polysphaeridium zoharyi* (Rossignol), *Spiniferites mirabilis* (Rossignol), *Spiniferites ramosus* (Ehrenberg) and *Spiniferites* sp. cf. *ramuliferus* (Deflandre). This assemblage suggests a warm, nearshore, marine depositional environment.

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INTRODUCTION

A Late Pleistocene sequence was intersected in the water bore WRC 39275, which is located approximately 10km southeast of Bulahdelah, N.S.W. (Fig. 1). This sequence consists of 42m of interbedded gravels, sands and clays which can be divided into three depositional units (Fig. 2). Below 18.8m the sequence consists of fluvial lithic sands, clays and gravels, between 18.8m and 11.5m it consists of estuarine/shallow marine clay culminating in fine- to medium-grained quartz sand, and above 11.5m it is composed solely of fine- to medium-grained quartz sand of the Pleistocene Inner Barrier system (Pickett, 1983; Drury, 1982). By an analogy with nearby deposits of known age Pickett (1983) assumed the sequence to be associated with the Last Interglacial and therefore to be approximately 120,000 years old.

Four samples were investigated: from 9-11m, 14.2-18.8m, 28.0-38.8m and 40.5-40.8m. The lower three samples yielded microfloras but only one, from 14.2-18.8m, yielded a dinoflagellate cyst assemblage. This latter interval also contained foraminiferal and molluscan assemblages (Pickett, 1983). The spore-pollen component of the palynomorph assemblages is dominated by *Casuarina* (11.0-25.4%), Myrtaceae (37.5-43.0%) and *Cyathea* (10.0-29.0%); dinoflagellates comprise less than 0.5% of the uppermost assemblage and were not recovered from the underlying samples.

The samples were prepared according to standard palynological procedures, although they were not oxidized as even mild oxidation has been observed to destroy some cyst types (Dalè, 1976). Palynological preparations are located in the palynological collection of the Geological Survey of N.S.W.

DINOFLAGELLATES

Fossil dinoflagellate cysts have been used extensively both to determine the age and to provide information on the depositional environments of Mesozoic and Tertiary marine sequences. Until relatively recently, however, the study of Quaternary dinoflagellate cysts has been neglected and even now is virtually restricted to the northern hemisphere. Pleistocene dinoflagellate cyst assemblages have previously been described from Great Britain (Harland and Downie, 1969; Harland, 1977; Wall and Dale, 1968; West, 1961), the North Atlantic Ocean (Harland, 1979; 1984a; 1984b), the Caribbean

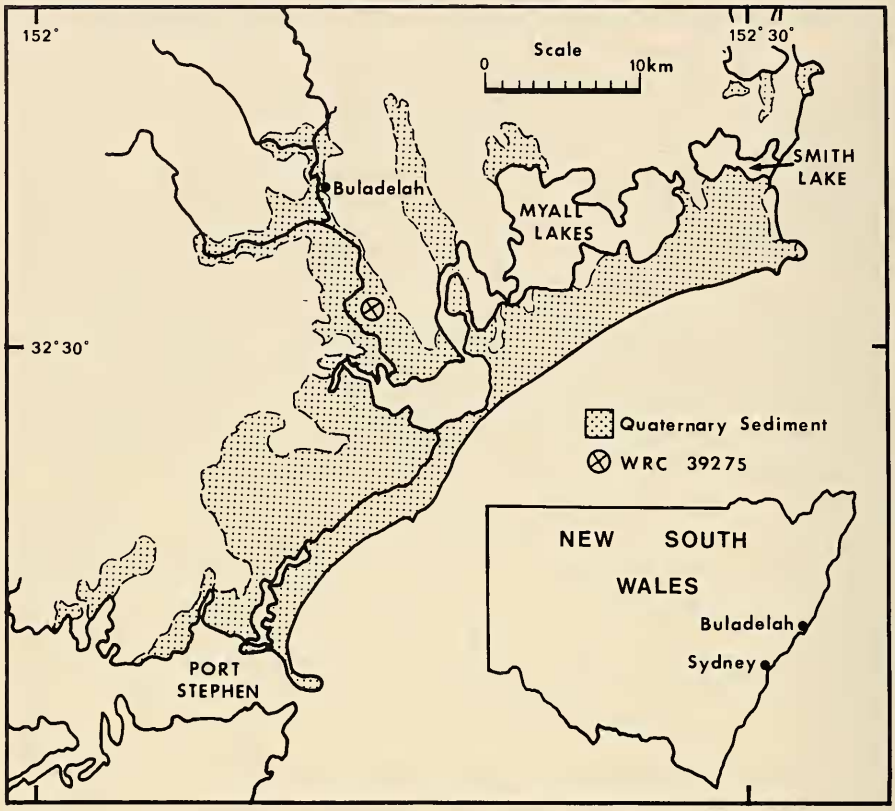

Fig. 1. Location of the bore WRC 39275 (Map reference: Newcastle 1:250 000 sheet, G.R. 5279 9865).

Sea (Wall, 1967), the North Sea (Harland *et al.*, 1978), the Black Sea (Wall *et al.*, 1973; Wall and Dale, 1973; 1974), Japan (Matsouka, 1976a; 1976b), Matsouka and Nishida, 1973), New Zealand (Wilson, 1973) and from Israel (Rossignol, 1962; 1964). There is no published account of Australian Pleistocene marine dinoflagellate cysts.

Six species, however, were recorded from Bulahdelah; these are:

Protoperidinium (*Protoperidinium* sect. *Quinquecuspis*) *leonis* (Pavillard) Balech 1974; Figs 3**A-F**.
Tuberculodinium vancampoae (Rossignol) Wall 1967; Figs 3**J-K**,**M-N**.
Spiniferites mirabilis (Rossignol) Sarjeant 1970; not illustrated.
Spiniferites ramosus (Ehrenberg) Mantell 1854; Figs 3**H**,**I**,**L**.
Spiniferites sp. cf. *ramuliferus* (Deflandre) Reid 1974; not illustrated.
Polysphaeridium zoharyi (Rossignol) Bujak *et al.* 1980; Fig. 3**G**.

The relative abundance of each species in the dinoflagellate assemblage is shown in Fig. 2. Absolute dinoflagellate abundance is low, being less than two cysts per gram of sediment. This compares with abundances of up to 14,000 cysts per gram in Pleistocene assemblages from Great Britain (Harland and Downie, 1969). The total number of dinoflagellate cysts observed was 54.

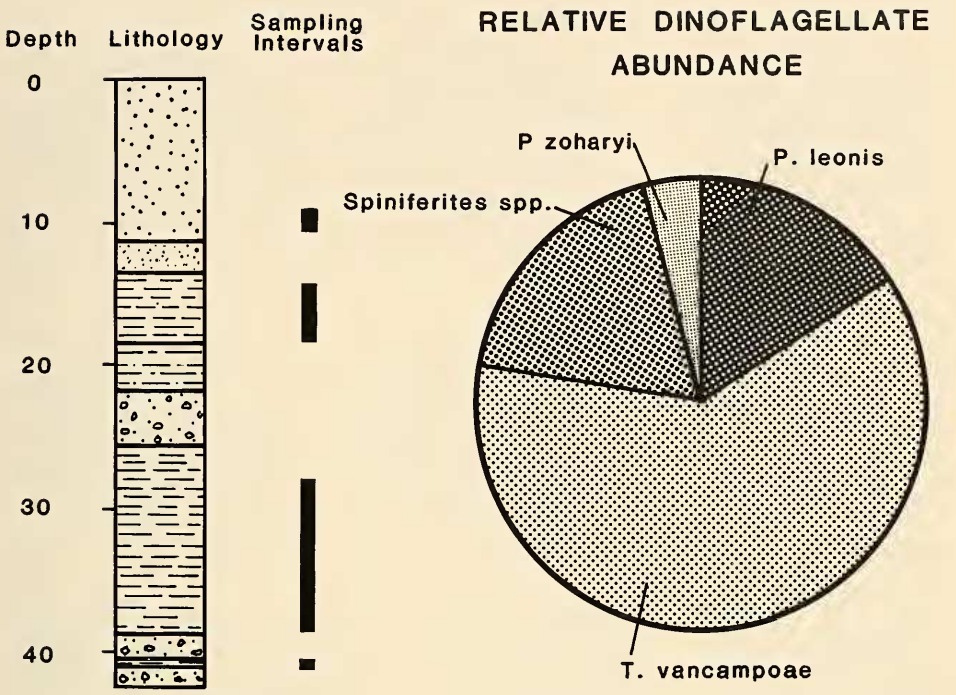

Fig. 2. Stratigraphic column, sample positions and dinoflagellate cyst abundance in the bore WRC 39275.

Recent Distribution of Recorded Dinoflagellate Cysts

Cysts of *Protoperidinium* (*Protoperidinium* sect. *Quinquecuspis*) *leonis* have been recorded from coastal areas around Great Britain, from the Caribbean and from off the coast of West Africa (Harland, 1983), and from Japan (Matsouka, 1976a). Harland (1983) suggested that this species has a tropical to temperate distribution in inner and outer neritic environments. The thecate form of this species has been recorded extensively around Australia (Wood, 1954).

Cysts of *Tuberculodinium vancampoae* have been recorded from the southern coast of eastern U.S.A., Bermuda, Bahamas, Puerto Rico, Peru and the Mediterranean Sea (Wall *et al.*, 1977), from the Persian Gulf and Red Sea (Bradford, 1973; 1975; Wall and Warren, 1969), Israel and the eastern Mediterranean Sea (Rossignol, 1962; 1964), Japan (Matsouka, 1976b; 1981; Harada and Matsouka, 1974; Shimakura *et al.*, 1971). Wall *et al.* (1977) noted that the maximum concentration of this species was in estuarine environments. Harland (1983) also observed that *T. vancampoae* was more common in tropical to subtropical areas. The highest latitude at which this cyst has been recorded is approximately 40 degrees north, in Japan. In the Australasian region the thecate form of this species (*Pyrophacus vancampoae* (Rossignol), Wall and Dale, 1971) is common in the Coral Sea and other northern seas but also extends south along the N.S.W. coastline at least as far as Sydney Harbour (new data) and Port Hacking (C. Hallegraeff, C.S.I.R.O. Marine Laboratory *pers. comm.*).

Polysphaeridium zoharyi has been recorded from Bermuda, Puerto Rico, southern coast of eastern U.S.A. and the Mediterranean Sea (Wall *et al.*, 1977), Israel and the

eastern Mediterranean Sea (Rossignol, 1964; Rossignol and Pastouret, 1971), Persian Gulf and Red Sea (Bradford, 1973; 1975; Wall and Warren, 1969), the Black Sea (Roman, 1969) and Japan (Harada and Matsouka, 1974). Harland (1983) suggested that most of the reported northern European occurrences are probably misidentifications and that *Polysphaeridium zoharyi* is apparently restricted to tropical and subtropical areas. It is also apparently more abundant in estuarine and nearshore environments. In the Australasian region the thecate form of this species (*Pyrodinium bahamense* Plate 1906) has not been recorded south of New Guinea (C. Hallegraeff *pers. comm.*).

Cysts of *Spiniferites mirabilis*, *Spiniferites ramosus* and *Spiniferites* sp. cf. *ramuliferus* each have a cosmopolitan distribution. The thecate form of *Spiniferites mirabilis* and *Spiniferites ramosus* (i.e. *Gonyaulax spinifera* (Claparede and Lachmann), Diesling, 1866; Wall and Dale, 1970) is also widely distributed in the Australian region (Wood, 1954); the thecate form of *Spiniferites* sp. cf. *ramuliferus* is not known.

Discussion

The composition of the Bulahdelah assemblage bears little resemblance to any previously described assemblage. Wall *et al.* (1977) described 168 dinoflagellate cyst assemblages from a wide variety of modern marine and estuarine environments but they recorded a maximum abundance of *Tuberculodinium vancampoae*, the dominant species at Bulahdelah (66% of the assemblage), of only 11%. The unusual composition of the Bulahdelah assemblage, therefore, creates difficulties in postulating possible depositional environments. The geographically closest described Pleistocene assemblages are from the middle Pleistocene Te Piki bed, New Zealand (Wilson, 1973). These assemblages are all dominated by *Bitectatodinium tepikiense* Wilson 1973, a species usually associated with temperate and cold temperate environments and not recorded from Bulahdelah. The abundance of this species in modern environments (maximum 11% (Wall *et al.*, 1977)) does not approach that reported in the Pleistocene of New Zealand (43% to 100%). At this stage no explanation can be given for the dominance of these two species which are usually only minor elements of an assemblage.

The absence of detailed Recent cyst distribution data for the Australian region prevents a comparison of the Pleistocene Bulahdelah assemblage with modern cyst assemblages from known depositional and climatic environments; interpretations based on cyst assemblages from the northern hemisphere will of necessity rely on extrapolations. However, when those data are combined with data on the present distribution of thecate dinoflagellates in the Australasian region (Wood, 1954) it can be inferred that the Bulahdelah assemblage was deposited in a subtropical estuarine/shallow marine environment. This conclusion is consistent with results determined from foraminiferal and molluscan faunas (Pickett, 1983).

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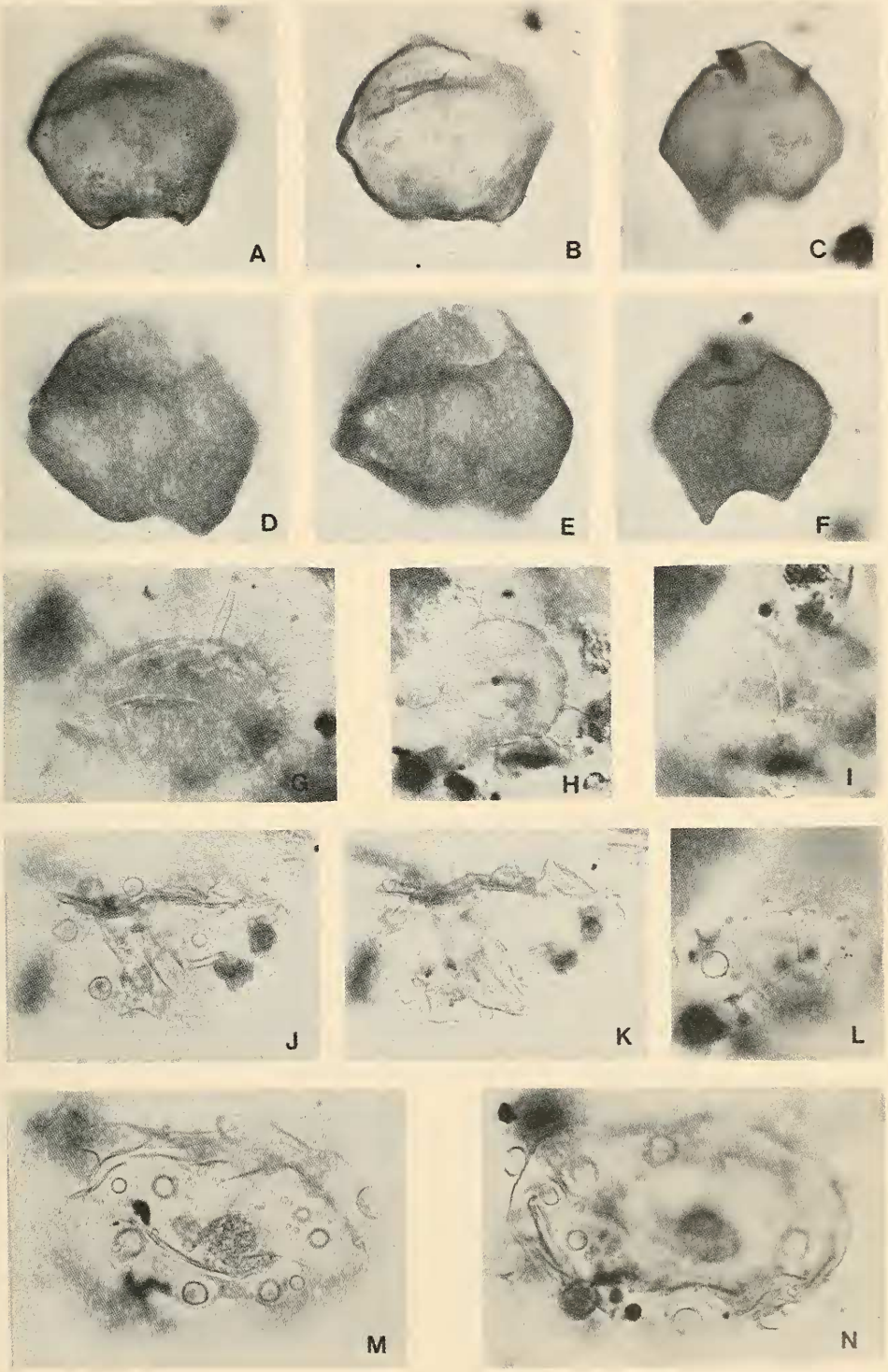
Fig. 3. **A,B** *Protoperidinium* (*Protoperidinium* sect. *Quinquecuspis*) *leonis* MMMC 01771; **C,F** *Protoperidinium* (*Protoperidinium* sect. *Quinquecuspis*) *leonis* MMMC 01772; **D,E** *Protoperidinium* (*Protoperidinium* sect. *Quinquecuspis*) *leonis* MMMC 01773; **G** *Polysphaeridium zoharyi* MMMC 01774; **H,I,L** *Spiniferites ramosus* MMMC 01775; **J,K** *Tuberculodinium vancampoae* MMMC 01776; **M,N** *Tuberculodinium vancampoae* MMMC 01777.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